A Method for the Fast T2 Measurement of Cardiac Masses

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Introduction: Echocardiography, CT, and MRI are used clinically for the identification and anatomical information on cardiac masses; however, determining the nature of cardiac masses is a challenging problem. Black-blood T2-weighted images, with data acquired at two different TE values, are typically used for imaging cardiac masses. The images at different TE's are used to visualize the mass and attempt characterization based on the qualitative evaluation of signal intensity changes. The drawback of the method is that the acquisition of high-resolution black blood images with different T2-weighted contrast is time consuming (typically a breath hold per slice is needed to acquire data at each TE). Moreover, mass characterization is based on the qualitative evaluation of the data. Here we present a method for the rapid localization of cardiac masses and their possible characterization based on T2 value. The method consists of a rapid black-blood scan through the heart to localize the mass followed by a high-resolution scan to measure T2. The pulse sequence used for the localization of the mass is an ECG triggered double-inversion single-shot fast spin-echo (DIR SSFSE) [1]. The pulse sequence used for obtaining T2 information on the mass is an ECG triggered double-inversion radial fast-spin-echo (DIR RAD-FSE) [2]. The acquisition of data for localization and characterization can be as short as two breath holds.

Methods: The DIR SSFSE and DIR RAD-FSE pulse sequences were implemented on a 1.5T GE Signa NV-CV/i MRI scanner equipped with 40 mT/m gradients, using a four-element phased-array torso coil for signal detection. The acquisition parameters for the DIR SSFSE scan were: TR= 2R-R, TE_{eff} ~30 ms, acquisition matrix = 256 x 160, BW = ±62.50 kHz, slice thickness = 7mm. With these parameters 13 slices may be obtained in ~21s (depending on heart rate).

The parameters for the DIR RAD-FSE sequence were: ETL=16, 160 radial lines, 256 points along each line, BW = ±32 kHz TR = 2R-R, NEX=1, slice thickness = 7 mm. With the DIR RAD-FSE a data set for one slice was acquired in ~24 s (depending on heart rate). Images at various TE_{eff} were generated from the single radial k-space data set (acquired in one breath hold) using data corresponding to a specific TE in the central part of k-space, up to a radius determined by the Nyquist condition. Radial data acquired at $TE \neq TE_{eff}$ were incorporated in a progressive manner from the Nyquist point to the outer part of k-space[3]. Interpolation and complex filtered back projection were used to reconstruct images. T2 maps were generated by fitting the pixel intensity on the T2-weighted images, I, to $I = I_o e^{\frac{-TE_{eff}}{T2}}$.

Results: Images of a patient with a mass pathologically characterized as a sarcoma are shown in Figures 1 and 2. Figure 1 shows the localization of the mass done in a single breath hold with the DIR SSFSE sequence. Figure 2 shows images of a slice through the mass acquired in a second breath hold with DIR RAD-FSE. Figure 2a is the anatomical image generated from the full k-space radial data set. Figures 2b-d are three (out of 16) images at different TE_{eff} obtained from the same radial k-space data set processed as indicated above. The T2 map calculated from the TE_{eff} images is shown in Fig. 3a along with the T2 maps for a cyst (Fig. 3b) and a thrombus (Fig. 3c). Note that each mass shown in Fig. 3 has a distinct T2 value.

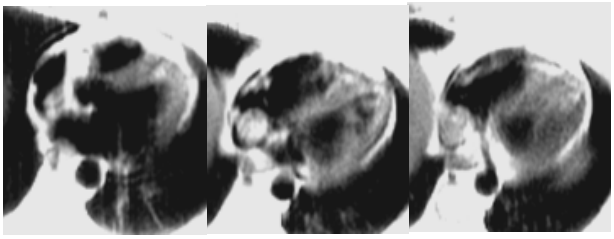

Fig. 1 . Localization of cardiac mass. Three out of the 13 axial slices acquired with DIR SSFSE in a breath hold

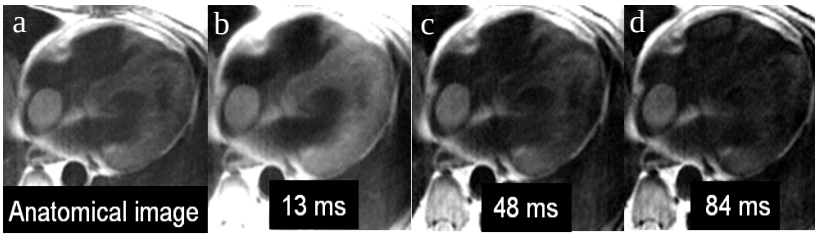

Fig. 2. Images at three different TE_{eff} generated from a single k-space data set acquired with DIR RAD-FSE

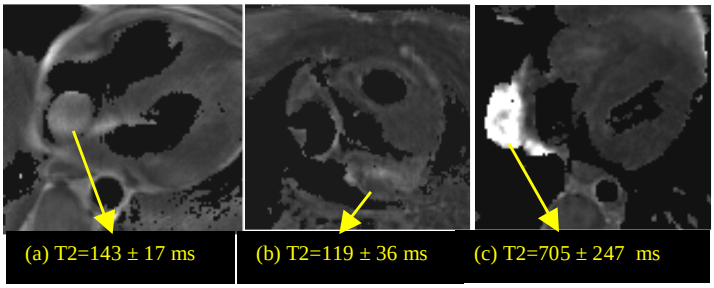

Fig. 3. T2 maps of (a) a sarcoma (b) a thrombus, and (c) a cyst

Conclusion: A fast method for the localization of cardiac masses, obtaining high resolution anatomical images, and T2 maps has been presented. With this methodology the diagnosis of cardiac masses can be performed rapidly and efficiently. The method may be used to provide information for characterizing a mass and/or to follow changes within a given mass over time.

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References: [1] Stemerman D et al, Radiology, 213, 185, 1999; [2] Altbach et al, SCMR abstract published in J Cardiovasc Magn Reson, 6, 9, 2004. [3] Altbach et al, ISMRM, 11, 1070, 2003.